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Title:
Maritime navigation and radiocommunication equipment and systems - Integrated navigation systems (INS) - Operational and performance requirements - Methods of testing and required test results
(Titre) :

IEC 61994 was set up as a work item at the request of the marine electronics industry in order to produce an International Standard embracing modern technology that was becoming more common on ships. The lack of regulatory requirements in an otherwise very regulated marine industry led to a decision to produce a first draft that was sent to the International Maritime Organisation (IMO) for comments. As a consequence, IMO produced a new work item, the results of which became IMO Resolution MSC 86(70) Annex 3 in December 1998.

All further work by WG 10 of TC80 has been based on this MSC Resolution. However, working in a technological environment which, in the marine industry at least, is not mature has been a considerable burden on the working group. Other IEC publications on similar subjects, specifically IEC 61209 Integrated Bridge Systems, have not been of help to advance the work.

At the beginning of the work, it was felt that small ship equipment could not be overlooked as it was probably on those ships that the need for Standardisation was needed most. This led to the concept of three categories of INS. However, during the course of the work, with increasing needed requirements, it now appears that this draft International Standard does not address adequately the requirements for small ships equipment. Further work is also needed in this respect.

As a result, WG10 received agreement from its parent body TC80, to circulate the results of the work as a CD, even if it felt that the document is not yet suitable for publication. It is hoped that the National Committees will consider carefully this document and comment on it in order to accelerate the ongoing work.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS -

Integrated Navigation System (INS) Operational and Performance requirements - Methods of testing and required test results

FOREWORD

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International Standard IEC 61924 has been prepared by working group 10, of IEC technical committee 80:

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that this publication remains valid until a new or complementary IMO Resolution has been published. At this date, in accordance with the committee's decision, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

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Square brackets are included in every place where full consideration has not yet been given to the text.

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1 Scope

This International Standard specifies the minimum requirements for the design, manufacture, integration, methods of testing and required test results for an integrated navigation system (INS) to comply with the International Maritime Organisation (IMO) requirements of Resolutions MSC 86(70) annex 3. *The purpose of an Integrated navigation system (INS) is to provide 'added value' to the functions and information needed by the officer in charge of the navigational watch (00W) to plan, monitor or control the progress of the ship.* (MSC 86(70), 1.1).

It also includes the requirements of IMO Resolution A.694(17) - General requirements – to which IEC 60945 is associated. When a requirement in this standard is different from IEC 60945, the requirement in this standard shall take precedence.

1.2 The INS supports mode and situation awareness. (MSC 86(70), 1.2)

1.3 The purpose of this International Standard is to support proper and safe integration of navigational equipment and information. (MSC 86(70), 2.2).

1.4 The INS generally consists of the equipment required for functional integration as defined in this International Standard. The sensors and actuators, only required for the input and output data, are not part of the INS.

1.5 This International Standard *defines three categories of INS*:

- INS(A) for systems that provide the minimum functional requirements of the INS, including a consistent common reference system. (MSC 86(70), 2.3.1);
- INS(B) for systems that, in addition to the functional requirements of INS(A), provide the information needed for decision support in avoiding hazards (MSC 86(70), 2.3.2); and
- INS (C) for systems that, in addition to the functional requirements of INS(B), provide the automatic control functions of heading, track or speed. (MSC 86(70), 2.3.3).

1.6 This International Standard aims to resolve conflicts that may occur from the differences in the requirements for individual navigational aids forming part of or connected to the INS. [Such resolution may imply deviation from individual standards for navigational aids. This International Standard highlights those specific deviations as well as their justification.]

1.7 *The function of passage execution in an Integrated Bridge system (IBS), as defined* by IMO in Resolution MSC64(67) annex 1 – Recommendation on performance standards for Integrated Bridge Systems (IBS) and related IEC 61209, *may be performed by an INS* which should at least be an INS B. (MSC 86(70), 1.5).

NOTE: All text of this standard whose meaning is identical to IMO SOLAS Ch. V, Resolutions A.694(17), as detailed in IEC 60945, and MSC 86(70) annex 3, is written in *italics* and is followed by the Resolution and paragraph numbers indicated in brackets at the end of the relevant paragraph e.g. A.694(17) 4.2

NOTE: Each subclause number of the tests detailed in clause 10 and following, is followed by the clause number of the related requirement in clauses 4 to 9.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60092-101 (1994-10) Electrical installations in ships - Part 101: Definitions and general requirements

IEC 60945(Ed 4) Marine navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results

IEC 60533 (1999-11) Electrical and electronic installations in ships - Electromagnetic compatibility

IEC 61209 (1997) Integrated Bridge Systems (IBS)

ISO 3791 (1976) Office machinery and data processing equipment – Keyboard layouts for numeric applications.

IMO International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974), as amended; and Protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974 (SOLAS Protocol 1973/78), as amended

IMO Resolution A.694(17): General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational aids.

IMO Resolution A.817(19): Performance standards for electronic chart display and information systems (ECDIS) (See also IMO Resolution MSC.64 (67))

IMO Resolution A.830(19): Code on Alarms and Indicators, 1995

IMO MSC Resolution IMO Resolution MSC 86(70) ANNEX 3 Recommendation on Performance Standards for an Integrated Navigation System (INS)

ISO 9000-3 (1991): Quality management and quality assurance standards - Part 3: Guidelines for the application of ISO 9001 to the development, supply and maintenance of software

ISO 9001 (1993): Quality systems - Model for quality assurance in design/development, production, installation and servicing

ISO 9002 (1993): Quality systems - Model for quality assurance in production and installation

3 Definitions and abbreviations

3.1 Definitions

For the purpose of this standard the following definitions apply:

Added value
The added value is the functionality and information that are provided by the INS in addition to the requirements of the performance standard for each individual equipment.

Accuracy
The degree of conformance between the estimated or measured parameter at a given time and its true parameter at that time.

Automatic control system
A control system that may include a heading, track or speed control system.(MSC 86(70), 3.1)

Confidence level
The probability that a given statement is correct, or [the probability that a stated confidence interval (numerical range) includes an unknown.]

Configuration of complete system
All operational functions and subsystems of the INS as installed.

Configuration available
Subsystems allocated to and available at any workstation.

Configuration in use
Subsystems currently in use at any workstation.

Connectivity
A complete data link and the presence of valid data.

Consistent common reference system
A sub-system of an INS for acquisition, processing, storage and distribution of data and information providing identical and obligatory reference to sub-systems within an INS. (MSC 86(70) 3.2)

Essential information
Information that is necessary for the monitoring and control of functions required for the safe navigation of the ship.

Functionality
Ability to perform an intended function. The activity of performing a function normally employs a system of displays, controls and instrumentation.

IMO requirements
IMO Conventions, Regulations, Resolutions, Codes, Recommendations, Guidelines, Circulars and related IEC and ISO standards, and ITU Radio Regulations and Recommendations.

Indicator
Visual indication giving information about the condition of a system or equipment. (IMO Res. A.830 (19))

Integrated navigation system
An INS is a combination of systems that are interconnected to increase safe and efficient navigation when used *by suitably qualified personnel.* (MSC 86(70), 3.3)

Integrity
Ability of the system to provide the user with information within the specified accuracy in a timely, complete and unambiguous manner, and alarms and indications within a specified time when the system should be used with caution (doubtful integrity*) or not at all.* (MSC 86(70), 3.4)

Latency
Time interval between an event and its resulting information, including time for processing, transmission and reception.

Manufacturer
The organisation responsible for the production of some or all of the parts of the INS, including the responsibility that these parts meet their individual international standards. A manufacturer may also be the system integrator.

Multifunction display
A single visual display unit that can present, either simultaneously or through a series of selectable pages, information from more than one operation of a system (MSC 86(70), 3.5).

Mode
The actual setting of a group of parameters determining the behaviour (operational modes) or the Human Machine Interface (HMI) (display modes) of the equipment or its sensors.

Navigation
The process of planning, recording and controlling the safe and expeditious movement of a craft from one place to another.

Navigational aid
An item, e.g. instrument, device or chart, carried on board and intended to assist the navigation of a craft.

Part
An individual subsystem, equipment or module

Primary Navigation Data
Navigation data provided by sensors to the INS(A) as required to perform its functions: position, speed, heading, and time.

Performance Standard
An IMO Performance Standard as annexed to an Assembly or MSC Resolution.

Receiver Autonomous Integrity Monitoring
Function of a position receiver, using a reference system for position integrity calculations which is independent from the system providing the primary position data.

Radar plotting device
A radar plotting as implemented in ARPA, ATA or EPA.

Reliability (System)
The probability of performing a specified function without failure under given conditions for a specified period of time

Sensor
A navigational aid, with or without its own display and control as appropriate, automatically providing information to the INS. (MSC 86(70), 3.6)

Situation awareness
The perception, of the elements of the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.

System data (SD)
Data, marked as such, to be used within the INS.

System integrator
The organisation responsible for the system design, integration and commissioning of the installed INS system. A system integrator may also be a manufacturer.

Validity
***t.b.d. See 61162-1

Workstation
Position at which one or several tasks constituting a particular activity are carried out.

Workstation for INS
Workstation at which the primary functions for navigation, traffic surveillance and manoeuvering are carried out in accordance with the requirements of this Standard.

3.2 Abbreviations

AIS	Automatic identification system
ARPA	Automatic radar plotting aid
ATA	Automatic tracking aid
CCRS	Consistent common reference system
DR	Dead reckoning
ECDIS	Electronic chart display and information system
EUT	Equipment under test
EPA	Electronic plotting aid
EPFS	Electronic position fixing system
GNSS	Global navigation satellite system
HCS	Heading control system
HMD	Heading measuring device

HMI	Human machine interface
IBS	Integrated bridge system
IMO	International Maritime Organisation
IEC	International Electrotechnical Commission
INS	Integrated navigation system
ISO	International Standards Organisation
ITU	International Telecommunication Union
LORAN	Long range navigation system
MFD	Multifunction display
OoW	Officer in charge of the navigational watch (Officer of the Watch).
RP	Radar plotting as defined by ARPA, ATA or EPA.
SD	System data
SDME	Speed and distance measuring equipment
TCS	Track control system
THD	Transmitting heading device
TMHD	Transmitting magnetic heading device
VDU	Visual display unit
VDR	Voyage data recorder

4 Common requirements for all categories of INS

4.1 Introduction

This International Standard defines three categories of INS (See 1). The requirements of this clause are applicable to all three classes of INS. They include the applicable general and operational requirements of IEC 60945. The requirements specific to INS(A), INS(B) and INS(C) are detailed in 6, 7 and 8 respectively.

When no method of test is detailed in 10 and the following clauses for a requirement contained in this clause and in 5, 6, 7 and 8, the manufacturer shall declare compliance with these requirements and shall provide relevant documentation. The declarations, documentation and where necessary, the EUT shall be checked.

The manufacturer shall also declare the composition of the EUT and the category to IEC 60945 for each unit of the EUT.

4.2 General

In addition to meeting the relevant general and operational requirements *of Resolution A.694(17)* to which IEC 60945 is associated, *the INS shall comply with the requirements of the IMO Performance* Standards MSC 86(70) Annex 3, as clarified in this International Standard. (MSC 86(70), 4.1.1).

The purpose of an integrated navigation system (INS) is to provide 'added value' to the functions and information needed by the officer in charge of the navigational watch (00W) to plan, monitor or control the progress of the ship. (MSC 86(70) 1.1) The added value shall be declared by the system manufacturer/integrator.

Each part of the INS shall comply with the applicable requirements adopted by IMO, including the requirements of IMO resolution MSC 86(70), as detailed in this International Standard. Parts executing multiple operations shall meet the requirements specified for each individual function they can control, monitor or perform. (MSC 86(70), 4.1.2)

The INS shall *support mode awareness* (MSC 86(70),1.2). If the INS supports more than one mode, the mode in use shall be clearly indicated. An indication of any other mode available, shall be accessible on demand.

If the mode in use is not the normal mode to fully perform the functions required for its category, this shall be displayed by clear text, including appropriate colour coding of the indication (see 0). Modes other than the normal mode of operation are, e.g.

- ‘fall-back modes’, in which the INS does not fully perform all functions of its category. For instance, for an INS (C) typical fallback modes are those which still support the required functions of INS (B) or (A).
- ‘test‘, ‚trial‘, ‚service‘, ‚simulation‘ or other modes, in which the INS shall not be used for navigation at all, or with caution only.
- If there are several control modes available for automatic control of the ship’s motion , selectable by the operator, the active modes of control shall be clearly and continuously at a similar location at each INS workstation. The indications shall be colour coded for mode status other than normal. See 4.16.3.

If there are several displays available to be selected by the operator to suit certain tasks, the INS shall indicate its mode of display in clear text and at a similar location at each of its displays. In a display mode, which is not suitable for navigation, e.g. a planning display in which the present ship's position is not shown or updated, the display indicator must be marked with a indication colour code as per 4.16.3.

The INS supports safety of navigation by evaluating inputs from several independent and different sensors, combining them to provide information giving timely warnings of potential dangers and degradation of integrity of this information. Integrity monitoring is an intrinsic function of the INS (MSC 86(70), 1.3) as required by its category.

The INS aims to ensure that, by taking human factors into consideration, the work load is kept within the capacities of the OoW and other mariners on the bridge in order to enhance safe and expeditious navigation and to complement the mariner’s capabilities, while at the same time to compensate for their limitations. (MSC 86(70), 1.4). The compensation of the OoW limitations shall be performed by the INS as required by its category.

[All functionalities of the INS shall be available at one designated workstation.]

When equipment or functions of equipment connected to the INS provide facilities in addition to this International Standard, the operation and, as far as is reasonably practicable, the malfunction of such additional facilities shall not degrade the performance of the INS below the requirements of this International Standard (MSC 86(70), 4.1.3).

4.3 Basic functions

An INS shall *combine, process and evaluate data from* at least *all sensors in use* as required for the integrity evaluation as per 4.3 (MSC 86(70), 4.1.5)

An INS shall ensure that the different types of information are distributed to the relevant parts of the system, applying a ‘consistent common reference system’ for all types of information. (MSC 86(70), 4.1.6).

[As a minimum, the following consistency checks shall be performed:]

a) [It shall be possible to define only one location at the ship as the reference for all position related information, at one time.]
b) [All position information shall be distributed and displayed in the WGS 84 projection and Lat / Lon convention and from the same source throughout the system. The information shall be distributed with a numeric resolution capable to support the accuracy or precision

specification stated by the manufacturer or, in absence of such statement, with a resolution of one thousandth of a “minute”. If the distribution or display of position does not conform to the above, the position information, and information derived from it, shall only be displayed with an indicator].

c) [If the system is capable to display athwartship speed information, it shall be possible to define only one location at the ship as its reference, at one time. If the system is capable to display athwartship speed information for a second location, then it shall be possible to define only one location at the bow and a second location at the stern of the ship as references, at one time. All speed information of the same type, distributed or displayed throughout the system, shall be from the same source.]

d) [All speed information shall be distributed and displayed with a resolution of at least one tenth of a knot up to 9.9 Kt, and with a resolution of at least one knot for higher values. For longitudinal speed information, the direction may be indicated with the signs “+” for the forward and “-“ for the aft direction. An athwartship direction must be indicated by an arrow symbol]

e) [All depth information shall be distributed and displayed with a resolution of decimetres down to 9.9 meters, and with a resolution of one metre for greater depths. The display of depths shall be referenced to the keel (depth below the keel). The system may include the capability to display the depth from another level, e.g. from the water surface, and in such case the depth shall only be displayed with the indication of the reference and with a warning indication. If the system is capable to display depths from different locations, then all depth displays must include the indication of the referring location, e.g. “bow / stern” and/or “pt / stb”.]

f) [All heading or course information shall be distributed and displayed with a resolution of at least 0.1 degree, using the same source throughout the system.]

g) [All date and time information shall be distributed and displayed in a common time reference and using the same source throughout the system and shall complemented by the indication of the reference used: UTC, local, etc.]

h) [If the system is capable to distribute or display primary navigation data from sensors other than system data, these data and information therefrom derived shall only be displayed with an indicator].

i) [If the system processes or displays data or information from more than one sensor providing similar data, then the source sensor must be indicated, e.g. THD 1, THD 2, GNSS / DGNSS, EM-Log / Doppler, etc.]

j) [All primary navigation data shall be distributed throughout the system at intervals of no more than [0.1 sec] and consistent with the distributed system time to within [0.05 sec] For sensor data received with lower repetition rates, the related system data shall be automatically extrapolated for the time of distribution.]

4.4 Integration

The INS shall provide functional integration meeting the following requirements

a) *Where a display or control is presented on a multifunction display unit, then these displays, controls or multifunctional display units* shall *be redundantly available*; (MSC 86(70), 4.1.16.1).

4.5 Integrity monitoring

Essential information provided by the INS shall include an indication of its integrity.

The integrity of information shall *be verified by comparison of the data derived independently from two or more sources if available* (MSC 86(70), 4.1.10). (See annex B)

The integrity of essential information shall be *verified* automatically *before* such *essential information is displayed or used. Information with doubtful integrity shall be clearly marked by the INS and shall not be used for automatic control systems* (MSC 86(70), 4.1.11).

The integrity of data from different sensors shall *be evaluated prior to distribution.* (MSC 86(70), 4.1.5)

As a minimum, the following integrity measures shall be performed:

a) [The integrity of system position data shall automatically be checked with a RAIM function of the position sensor, or with a secondary position sensor, or with an estimated position derived from speed, heading and time sensor data. The position information shall be marked with a warning indication, if the deviation between the system position and the secondary position solution is greater than [two times the expected precision of the secondary position solution, or 10 times the expected accuracy of the primary sensor selected to provide the system position, whichever is smaller]

b) [The integrity of speed data shall automatically be checked with a secondary source of speed such as the propeller revolution, or a second speed sensing method of the speed sensor, or with the speed information provided by the position sensor. The speed information shall be marked with a warning indication, if the deviation between the system speed and the secondary speed solution is greater than [two times the expected precision of the secondary speed solution, or 10 times the expected accuracy of the primary sensor selected to provide the system speed, whichever is smaller]

c) [The integrity of heading data shall automatically be checked with a secondary heading sensor. The heading information shall be marked with a warning indication, if the deviation between the system heading and the secondary heading solution is greater than [two times the expected precision of the secondary heading solution, or 10 times the expected accuracy of the primary sensor selected to provide the system heading, whichever is smaller]]

d) [The integrity of time data shall automatically be checked with a secondary source of time data, which may be an internal time counter with a drift of no more than [2 min within 30 days of non-updated operation]. The time information shall be marked with a warning indication, if the deviation between the system time and the secondary time solution is greater than [two times the expected precision of the secondary time solution, or 10 times the expected accuracy of the primary sensor selected to provide the system time, whichever is smaller]

e) [Integrity checks performed by using data from sensors which may develop drift errors, such as speed, heading, or time, shall include both a short term check for the immediate acquisition of new data, as well as a long term check for the monitoring of possible slow degradations of integrity. The threshold values for generating warning or alarm indications in case of degraded integrity shall be included in the user manual. In case of automatic control of heading, course, track or speed, the threshold values shall automatically be reduced to indicators or alarm limits set for the control functions, as applicable.]

f) [Alternative and additional automatic methods of integrity monitoring may be provided, which result in at least the same level of confidence as those specified in 0 to 0 above. See Annex B.]

g) [Information from sensor data, which have been designated invalid by the sensor itself, shall be displayed only with an indication of “active alarm” according to 4.16.3, even if the integrity check does not otherwise detect a lack of integrity. Such information shall not be used for any automatic heading, course, track, or speed control functions.]

h) [The change of primary navigation information to the “doubtful status” shall be indicated by “active alarm, not acknowledged”, the change to an “integer status” shall be treated as acknowledgement, and the status “active alarm, acknowledged” shall be indicated.]

i) [Any other information with doubtful integrity shall at least be marked with a warning indication as per 0]

4.6 Display of information

The INS shall *be able to display the information available in accordance with paragraphs 4.1.7* (see 6), *4.1.8* (see 7.1) *and 4.1.9* (see 8.3) of Res. MSC 86(70) *as applicable.* (MSC 86(70), 4.2.1). The required display need not be a dedicated display.

The INS shall *be capable of displaying output data available from the sensors* as well as the information generated by the INS from such data. (MSC 86(70), 4.2.2).(see also MSC 86(70), 5.2.2)

The INS shall be capable of displaying systems data.

The information shall *be displayed together with the indication of its source (sensor data, result of calculation or manual input), unit of measurement and status, including mode* (see sub-section Integrity monitoring paragraph 4.1.10 of MSC 86(70). See 4.5.2) (MSC 86(70), 4.2.3) See also MSC 86(70), 5.1.1.

Continuously displayed information [1] shall be reduced to the minimum necessary for safe navigation of the ship. Supplementary information shall be readily accessible.

Any additional navigational information e.g. wind speed, may be displayed on an INS display, provided it does not mask, obscure or degrade the information required to be displayed by this International Standard.

4.7 Configuration display

It shall *be possible to display the complete system configuration, the available configuration and the configuration in use* (MSC 86(70), 4.1.17), as a graphic presentation or as a list.

4.8 Data management

The INS shall combine, process and evaluate data from all sensors in use. It shall select those data to be distributed to all components of the system, thus providing a common reference.

The INS may also combine, process and evaluate data from other sensors and aids to navigation. Validity status shall be included when available.

Data management shall be applied to the provisions listed under 4.15.3 and 4.15.4 as applicable.

Data management shall check quality of data from different sensors prior to selection. Quality parameters are accuracy, availability, integrity, latency, reliability and validity.

Corrupted data shall not be accepted by the INS. Corrupted or missing data shall not affect functions not dependent on these data.

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1 Continuously displayed information depends on the operations being integrated.

Examples may include but are not limited to:

- Demanded and current speed
- Heading
- Radar
- Ship’s speed and distance run
- Echo sounder depth
- Rate of turn
- ECDIS
- EPFS position
- Desired heading and steering mode

4.9 Data exchange

Stand alone equipment for which performance standards adopted by IMO exist, when connected to the INS, shall *comply with* IEC 61162 series *as applicable, for data exchange and interfacing* (MSC 86(70), 4.1.12).

Data latency shall *be consistent with the data requirements of the individual parts* (MSC 86(70), 4.1.13) for processing or displaying information according to the requirements of the relevant international standards, including this international standard.

Data latency shall be consistent with safe navigation. The manufacturer shall specify in the system specification document the maximum permissible latency for each function considering the use of fast control loop, normal control loop, essential information and other information

Data latency shall be checked and monitored at least for the information transferred to control loops.

See also 4.3.3.11.

The integrity of the data exchange within the INS shall be ensured (MSC 86(70), 4.1.14)

A failure of data exchange between parts of the system shall *not affect independent functionality* (MSC 86(70), 4.1.15).of the individual parts of the system

4.10 Interfacing

Interfacing to, and from, the INS shall *comply with International Standards, as appropriate*, namely IEC 61162 series, as applicable.(MSC 86(70), 7)

The network shall be such that in the event of a single fault between nodes, there shall be an indication of the fault and the sensors and displays on the network shall continue to operate. Data transmission between them shall be maintained.

4.11 Quality parameters

4.11.1 Accuracy

As a minimum, the accuracy of information shall *meet the requirements of the resolutions*[1] *adopted by* IMO.(MSC 86(70), 4.2.4) [for the individual navigational aids connected to or forming part of the system.]

Additionally the INS shall not degrade the [performance or*] accuracy of the data provided by the sensors* (MSC 86(70), 4.2.4).

In the INS, the precision of the navigation position solution shall be determined based on [redundant] measurements from sensor outputs of independent systems. This value shall be provided to the operator as a 95% confidence level.

4.11.2 Availability

The INS shall ensure that information required for functions in 5.1.3 is provided with at least the same availability as the data provided by the relevant sensor(s).

1 IMO Resolutions A.529(13) and A.815(19)

4.11.3 Consistency

TBD

4.11.4 Integrity

The INS shall continuously monitor the integrity of the system data as produced by the CCRS using validity, consistency and data cross-checking of the inputs.

4.11.5 Latency

The latency shall be suited to at least the process involved.

4.11.6 Validity

The INS shall provide functional integration meeting the following requirements:

a) validity [1] of the data shall be provided for each part to be integrated (MSC 86(70), 4.1.16).

The INS shall use information from sensors that provide their operational status and validity of essential information [2]. Where latency is available, it shall also be used within the INS.

4.12 Malfunctions

4.12.1 Failures

A failure of one part shall *not affect the functionality of other parts except for those functions directly dependent upon the information from the defective part.* (MSC 86(70), 4.1.4)

4.12.2 Fail safe operation

The system's automatic response to malfunctions shall *result in the safest of any other configuration accompanied by clear indications and alarms*.(MSC 86(70), 4.3.1)

4.12.3 Fall-back arrangements

The INS shall*, after a failure, support the availability of essential information through the use of appropriate fall-back arrangements.* (MSC 86(70), 8.1)

Normal operation, after use of a fallback arrangement, shall *only be restored upon confirmation by the operator* (MSC 86(70), 8.2).

In case of failure in one part of *an integrated navigation system, it* shall *be possible to operate each other individual item of equipment or part of the system separately* (SOLAS V/19.4)In accordance with the requirements of the relevant individual product standard.

4.12.4 Reversionary mode

The INS shall *allow simple and effective operator action to override or by-pass any automated functions. The INS* shall *resume automatic functions only after an appropriate message and*

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1 IMO Resolutions A.529(13) and A.815(19)

2 Essential information is the information that is necessary for the monitoring and control of functions necessary for the safety of the ship and depends on the operations being integrated.

Examples include but are not limited to:

- Heading, position, speed and depth
- Rudder angle
- Proximity to danger

intended operator action, thus allowing the operator the opportunity of considering all necessary starting conditions.(MSC 86(70), 4.3.2) (See also MSC 86(70) 5.2.2 in 4.16.2)

4.13 Alarms and indications

4.13.1 Alarm requirements

The INS shall alert the operator when the INS detects that the requirements of 4.11.1.3 are not fulfilled. The INS shall indicate the source of the alarm and advise the OoW on appropriate actions.

The INS shall alert the operator when speed through the water, speed over ground, heading and course values deviate from expected values. The INS shall indicate the source of the alarm and advise the OoW on appropriate actions.

4.13.2 Alarm management

An alarm management system shall *be provided* (MSC 86(70), 4.3.3) The INS shall provide alarms or appropriate indications when operator intervention is required.

The INS alarm management system, as a minimum, shall comply with the requirements of IMO Resolution A.830(19) (MSC 86(70), 4.3.4).

Appropriate alarm management on priority levels and grouping of alarm shall be provided in the INS. See Annex E.

The number of alarms shall *be kept as low as possible by providing indications for information of lower importance.* (MSC 86(70), 4.3.5).

Presentation of information relating to *alarms* shall *be displayed so that the alarm reason and the resulting functional restrictions can be easily understood. Indications* shall *be self-explanatory.* (MSC 86(70), 4.3.6).

An alarm display shall not obscure essential information. There shall be an indication if an alarm condition still exists. A list of all activated alarms must be available in chronological order, upon operator demand.

4.14 Software

The software shall meet the applicable requirements of IEC 60945.

The software in the INS shall be designed, developed, documented, produced, installed and serviced by the manufacturer or integrator certified to applicable ISO 9000 series standards. (Duplication. See 4.4)

Documentation of software shall consists of:

- system requirements specification;
- functional specification;
- high level flow diagram; and
- valid ISO certificate.

4.15 Cognitive ergonomics

Integrated display and control functions shall *adopt a consistent HMI philosophy and implementation* (MSC 86(70), 5.1.1).

The following functions and designations of their related controls and displays shall be consistent regardless of the mode of operation or mode of display, at least for the displays and operational controls of each INS workstation:

- the order of displaying the elements of sensor information:
  - type of data (mode), value, measurement units, source, and status.
- activating an input field, entering, editing, skipping, deleting or acknowledging an operator input,
- displaying the structure of an operation menu, calling up a menu item or entry or selection field, leaving a menu after or without performing an input,
- performing interactive graphical operations,
- selecting, storing, retrieving, calling-up or listing data from/to memory or to a data storage device,
- selecting or changing the mode of operation,

If abbreviations or symbols are used, they shall follow the requirements specified in IEC 60936 / 60872 (Radar / Radar plotter), or IEC 61174 (ECDIS) respectively, and if not specified therein, then IEC 61209 (IBS) or IEC 61162 (Interfaces) shall be used as reference in the order as listed here.

The HMI shall *be so designed that the provided information is clearly understood using a consistent presentation style.* (MSC 86(70), 5.1.2).

Each display shall be clearly divided into areas or “windows” (i.e. logical grouping of information) for different categories of information. The following elements of the HMI shall be consistent regardless of the mode of operation or mode of display:

- Individual displays shall not use different fonts for the same type of information of equivalent importance, except where the information is especially marked due to its status.
- The appearance of variable information shall be clearly distinguishable from that of the static one.
- Different displays or “windows” with similar appearance shall be differently designated.

At an INS workstation, the variable information elements shall be displayed with characters height in mm of less than 3,5 times the reading distance in metres, and the nominal character width shall be 0,7 times the character height. In case of INS(C), the variable elements of the following information shall be displayed with a character height of at least 7 mm or by graphical information of equivalent distance of readability.

- Heading and course over ground
- Speed through water
- Speed over ground and speed through water or drift angle
- Rate of turn
- Set heading, set course, set radius, and set speed
- Next heading, next course, next radius, and next speed
- Off course deviation, off track distance
- Time to wheel-over, distance to wheel-over

The colours of the INS display shall be optimally selectable for day and night operation.

Means shall be available to adjust brilliance of displays and control panels.

The HMI shall *be so designed that the requested manual inputs can be easily executed.* (MSC 86(70), 5.1.3).

In case of a graphical user interface, which allows or requests inputs from the operator, a pointer device shall be part of the HMI, by which any input field on the current display can be reached and activated within 2 seconds. The key for executing a command or acknowledging an input shall be clearly designated or differentiated by design from other adjacent keys.

In case the system requests an operator input, the relevant input field shall be automatically active and so marked for immediate operator entries.

In case the INS requires numerical or alphanumerical inputs, an ASCII-keyboard (or equivalent temporary keyboard window of the display screen) with the QWERTY arrangement of the keys shall be used. If a numerical keypad is connected, its keys shall be arranged in accordance with ISO 3791.

For manual inputs that may cause unintended results, and which, because of input errors, may lead to sudden manoeuvres or loss of data, *the INS shall request confirmation before acceptance, thus providing* the operator *the time for a plausibility check*. (MSC 86(70), 5.1.4).

All entries shall be checked by the INS, as far as practicable, for plausibility before they are further processed. An appropriate message including a proposed corrective action shall be displayed if an implausible entry has been made. An entry-field shall not be closed other than by a dedicated operator command to accept or cancel the entry or to skip the operation without accepting the entry.

4.16 Physical ergonomics

Particular consideration shall be given to:

- *symbols;*
- *controls; and*
- *layout* (MSC 86(70), 5.2.1); and
- colours; and
- information priorities

The INS shall *be designed and implemented so that the OoW easily operates basic functions from workstations* (MSC 86(70), 5.2.2).

All operator functions and related displays, controls and indicators required by this standard for any INS category shall be available at least at one INS workstation.

An INS workstation may consist of a maximum of 2 displays and associated controls which shall not be separated by more than 100 cm between the centres of the displays or no more than 160 cm between the outer limits of the displays or operator controls. The installation instructions shall include the necessary details.

An INS (C) workstation shall include dedicated and mechanically operated keys with status indicators for releasing, terminating or interrupting the heading, track or speed control mode. In case of multiple workstations with such controls, only one workstation shall at any time be ready for accepting commands, i.e. the “master station” for this function. Each workstation foreseen for master station capability shall be controlled by (a) mechanically operated key(s) with status indicator(s).

At each workstation, as a minimum, the following functions shall be available upon single operator command:

- resetting the display(s) into a predefined default mode,
- displaying any active status, warning or alarm message, which was previously acknowledged,
- changing the scale of a chart display,
- changing between heading, track or speed control modes,
- providing the controls and displays for:
  - settings for alarms and indicators limits (all INS categories)
  - sensor setting and monitoring functions (all INS categories),
  - settings for the geographical monitoring functions (INS (B) and (C)),
  - settings for the voyage plan (INS (B) and (C)),
  - settings for monitoring external and internal forces and effects, e.g. wind, drift, shaft revolutions, propeller pitch, engine power, etc.(INS (C)),
  - settings for control parameters and limits for heading, track or speed control and monitoring (INS (C))

Continuously displayed information shall be optimised and shall include position, speed, heading and time. Supplementary information shall be readily accessible (MSC 86(70), 5.2.3).

The following information shall always be displayed at the same location of the display, regardless of the display mode or mode of operation, except the “service” mode:

- Geographic position, (N/S - E/W)
- Speed through water
- Heading
- Time (UTC or local)
- System status / alarm symbol
- Display mode
- Mode of operation
- Display scale or range and orientation (INS (B) and (C))

The following information shall continuously be displayed in operation modes other than “open sea”:

- Rate of turn
- Speed over Ground (INS (C))
- Water depth below keel (where a depth signal is available).

The following information shall be immediately displayed upon occurrence of the relevant event in a format different and easily distinguishable from other information:

- alarms and warning messages, in clear text, together with recommended operator action
- changes of status
- changes of mode
- automatic change of the available system configuration.

If background or colour codes for status or mode indications are used, the following syntax shall be applied:

- red (blinking) active alarm status, not acknowledged
- red (static) active alarm status, acknowledged
- yellow (static) warning message active or status below normal but not critical

- green (or no status indication) normal status

These colour codes shall not be used for other indication purposes

If a “window” is used to display certain messages or information such window shall not cover any essential information on the display. The window shall immediately disappear from the screen upon single operator action, or after a time-out with no operator interaction of max. 5 sec.

4.17 Power supply

Power supply requirements applying to parts of the INS as a result of other IMO requirements, shall *remain applicable*. (MSC 86(70), 6.4).

The INS shall *be supplied:*

a) *from both the main and emergency source of electrical power with automated changeover through a local distribution board with provision to preclude inadvertent shutdown; and*

b) *from a transitional source of electrical power for a duration of not less than 45 s.* (MSC 86(70), 6.5).

The manufacturer shall declare that this arrangement is part of the INS under test or shall describe in the instruction manual (installation) the necessary means required.

If subjected to an orderly shutdown, the INS shall, upon turn-on come to an initial default state.

After a power interruption full functionality of the INS shall *be available after recovery of all subsystems. The INS shall not increase the recovery time of individual subsystem functions after power restoration.* (MSC 86(70), 6.6).

If subjected to a power interruption the INS shall, *upon restoration of power maintain the configuration in use and continue automated operation, as far as practicable. Safety related automatic functions, e.g. automated steering control* shall *only be restored upon confirmation by the operator.* (MSC 86(70), 6.7).

4.18 Maintenance

The equipment shall *be so designed that the main units can be replaced readily, for on-board repair, without elaborate recalibration or readjustment.* (A.694/8.1).

Equipment shall *be so constructed and installed that it is readily accessible for inspection and maintenance purposes.* (A.694/8.2)

4.19 Failure analysis

A Failure analysis [1] shall *be performed and documented at functional level for the configuration of the INS proposed to be installed which includes all parts connected to or integrated into the system, including devices for manual override of automatic functions and their proposed locations on the bridge.* (MSC 86(70) 6.2)

4.20 Quality assurance

The Administration shall require that the manufacturers have a quality control system audited by a competent authority to ensure continuous compliance with the type approval conditions. Alternatively, the Administration may use final product verification procedures where the

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1 See also IEC Publication 61508

compliance with the type approval certificate is verified by a competent authority before the product is installed on board ships. (SOLAS V, 18.4)

The INS shall be designed, developed, produced, installed and [where possible] serviced by companies certified to ISO 9001 or ISO 9002 as applicable with the purpose of applying both this international Standard and IEC 61508 as described in annex XX.

The system integrator shall ensure that the INS complies with this International Standard.

4.21 Maintenance

The equipment shall *be so designed that the main units can be replaced readily*, for on-board repair, *without elaborate recalibration or readjustment.* (A.694/8.1)

When checking the EUT for conformity with this requirement, due regard shall be given to any restriction likely to be imposed by the installation spatial environment

4.22 Equipment manuals

Adequate information shall *be provided to enable the equipment to be properly operated and maintained* by suitably qualified members of a ship's crew. (A.694/8.3)

4.22.1 Operating and servicing manuals

The operating and servicing manuals shall :

a) be written in English;

b) identify the category to IEC 60945 of the equipment or units to which they refer;

c) *in the case of equipment so designed that fault diagnosis and repair down to component level are practicable, provide full circuit diagrams, component layouts and a component parts list;* (A.694/8.3.1)

d) *in the case of equipment containing complex modules in which fault diagnosis and repair down to component level are not practicable, contain sufficient information to enable a defective complex module to be located, identified and replaced. Other modules and those discrete components, which do not form part of modules, shall also meet the requirements of 4.10 c) above.* (A.694/8.3.2)

4.22.2 Installation manuals

The installation manuals shall include adequate information to *allow the INS to be installed so that it can meet the requirements of the relevant international standards*, namely IEC 60092-101 and IEC 60533 (MSC 86(70), 6.3).

In addition, the installation manuals shall include:

- The approved configuration/s and all necessary information to allow this;
- The physical details of the permitted lay-out of the displays of the workstations;
- The details of the power supply arrangements required in accordance with 4.17.2;
- The physical details for installation in accordance with the requirements of 4.21.

4.23 Markings and identification

Each unit of the equipment shall be marked externally with the following information which, where practicable, should be clearly visible in the normal installed position :

a) *identification of the manufacturer*;

b) *equipment type number or model identification under which it was type tested*;

c) *serial number of the unit*. (A.694/9)

Alternatively, the marking may be presented on a display at equipment start-up.

The equipment shall be marked either before delivery to the ship, or on the ship at the time of installation.

The title and version of each software element included in the installed software system shall be either marked or displayed on command on the equipment.

When the marking and the title and version of the software are displayed only on the display, such information shall also be included in the equipment manual.

5 Environmental, special and safety requirements

The INS shall *meet the relevant requirements of resolution A.694(17)* and related IEC 60945 (MSC 86(70) 6.1).

6 Requirements applicable to INS(A)

6.1 General

The INS(A) shall, *as a minimum, provide the information of position, speed, heading and time, each clearly marked with an indication of integrity* (MSC 86(70), 4.1.7) [at a common display or indicator unit] and shall include a consistent common reference system.

Each such information shall consist of its source, value, dimension and status.

Indication of integrity may be the absence of the integrity indicator. In case of doubtful or insufficient integrity, at least the status display field shall be marked yellow *when the system should be used with caution (doubtful integrity) or* marked red, *when the system should be used not at all.* (MSC 86(70), 4.1.7) Means shall be available to the operator to positively verify, that the integrity indicator(s) are functioning.

7 Requirements applicable to INS(B)

7.1 General

The INS(B) shall, in addition to the functional requirements of INS(A),*be able to automatically, continually and graphically indicate the ship's position, speed and heading, and, where available* due to SOLAS carriage requirements, *depth in relation to the planned route as well as to known and detected hazards* (MSC 86(70), 4.1.8). [at a common display unit]

The size of the display shall meet the relevant requirement for readability as per IEC 60945 and ISO 8468, using the size of the connected navigation display as guideline. Known hazards are, as a minimum, those made available [via interface or data transfer] from an ECDIS or ENC [1]., [or otherwise , e.g. by means of a digitiser from the paper chart] Detected hazards are, as a minimum, those made available by tracked targets from an RP or radar [2]. The INS (B) shall include the editing, and storage functions for planning the route for a complete voyage, namely waypoints and their connections. The INS (B) shall include the graphical and numerical display of the planned course to steer, the distance to go to the next waypoint, and the cross track distance.

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1 see IEC 61174.

2 See IEC 60872 and IEC 60936 series

NOTE: ECDIS or RP are not necessarily part of the INS.

If the INS display is not an ECDIS, it must be ensured by system design [or by appropriate instructions in the user manual and warning indications at the display], that the known hazards are to be provided from an appropriate chart.

If the INS display is not an RP, it must be ensured by system design, that the detected hazards are provided from an radar plotter that meets the international standards.

If the INS uses its own display, which is neither an ECDIS nor a RP display, both above mentioned requirements must be fulfilled.

If the INS display is not an ECDIS, and no RP targets are received, the display shall include an appropriate indication with the instruction, that the RP functionality shall be checked

Where possible, AIS targets shall be displayed graphically co-related or merged with their related RP targets and, if installed, with the ECDIS chart objects.

Means shall be provided for the operator to define the RP and AIS target couplets for co-location.

The INS shall *support situation awareness.* (MSC 86(70),1.2)[as required by its category.

The INS shall make the operator aware of:

- the data of all connected navigation sensors,
- the technical status of each part of the INS,
- the modes of operation, display, and control (subject to the INS category)
- in case of INS (B) and (C), the nautical situation as per MSC 86(70) 4.1.8.

including their changes, and including appropriate alarms and indicators, see MSC 86(70) 4.3.6.

Consistent common reference system (CRS)

[To be expanded for INS (B) and INS (C) in addition to the requirements of 6.1.1]

7.2 Passage execution

7.2.1 Route planning

The INS integrates available and predicted information to optimise the route and predicted state parameters of the vessel.

The INS verifies consistency of planning data contained in integrated devices.

Results of planning are made available for verification.

The INS monitors and validates the inputs from the sensors and their data, and excludes invalid data.

[Means to input desired route including arrival times. TBD]

7.2.2 Passage planning

Passage planning shall be conducted by using the means available within the INS.

7.2.3 Requirements for passage planning

As a result of passage planning, the following information shall be available to the INS:

- planned way points;
- planned speed/time profile;
- planned track, planned track limits;
- planned manoeuvre limits.

7.2.4 Additional requirements for passage planning

To facilitate effective passage planning, the following information may be additionally made available from/to the INS:

- hydrographic data;
- weather [and sea current]data;
- ship's dynamic data.

8 Requirements applicable to INS (C)

8.1 Passage planning

The INS (C) shall be capable to automatically transfer way points to the connected Track Control System. Before transferring the way points, the INS(C) shall automatically check the area along the planned track including the planned turning radii for known and detected hazards within the track limit set by the operator. For this purpose, an operator may also define and enter a safety contour as a known hazard in addition to those known hazards eventually available in the system from an ENC data base. The track limit used by the system shall automatically be adapted to the track limit currently valid in the track control system. Additionally the track and the planned turning radii or rate of turn commands, if any, shall automatically be checked for the vessels capability to perform the required manoeuvres.

8.2 Passage monitoring

The INS(C) shall automatically monitor the area ahead of the ship and along the planned track including the planned turning radii for known and detected hazards, within a distance or time limit and within the track limit set by the operator.

8.3 Passage control

8.3.1 Control

The INS (C) shall, *in addition to the functional requirements of INS(B), provide means to automatically control heading, track or speed and monitor the performance and status of these controls* (MSC 86(70), 4.1.9).

For the purpose of automatic heading control, the INS (C) shall be connected to a heading control system complying with ISO 11674. In case of automatic track or speed control, the INS shall be connected to a track control system complying with IEC 62065. Alternatively, the INS (C) may perform the heading, track or speed control functions, provided it complies with the relevant standards.

NOTE: Heading control systems with only manual input of the "set heading" shall comply with the requirements of the relevant ISO standard1. Heading control systems with automatic input of the "set heading" as well as track or speed control systems shall comply with the requirements of this International Standard for INS (C) as well as the relevant ISO standard 2

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1 ISO 11674

2 IEC 62065, ISO 11674

8.3.2 Means for passage control

The INS shall provide [automatic] means to perform passage execution, based on information generated during passage planing, with special emphasis on:

- monitoring of sensor data and control loops;
- examination of the common reference;
- monitoring of track data;
- supervision of ship's manoeuvrability limits.

8.4 Passage recording

INS(C) shall provide a log of INS status, warning and alarms [for at least 12 hours of operation and which cannot be modified by functions available to the operator].

INS(C) shall provide a log for ship's position, course and speed, [and other data, at least as per the performance standard of ECDIS.]

9 General test conditions

9.1 General

For type testing purposes, those parts of the INS which have been type tested to the requirements of the individual standards, shall not need to be submitted to further testing. Only interfaces between the connected navigational aids, other inputs and the INS functionalities shall be tested as part of the tests required by this International Standard.

Conformance testing shall be carried out under normal test conditions and also, where stated, under extreme test conditions.

As a basis for testing the compliance with this requirement, the system integrator shall provide a thorough failure analysis which, in case of INS (C), shall be performed according to the requirements of IEC 61508, as a minimum in the form of:

- A list of potential failures and their possible effect on the performance of system functions; and
- A list of all automatic [warning] and alarm messages, including a description of related alarm contacts, including fall-back arrangements and including recommended operator actions to prevent hazardous consequences or consequential failures.

The failure analysis shall be structured [in order of priority/by the alphabetical order] of the [warning] and alarm messages and shall form part of the INS operator manual. In the case of INS (C), a graphical plan of the bridge shall be included, highlighting the locations of the work stations, indicators and operator controls of the INS.

The list of indicators and alarm messages shall include all indicators and alarm messages and alarm contact operations generated by all parts of the INS also for incidents not related to INS functions required by this standard.

a) Parts, functions and connectivity shall be identified.
b) Possible failures of parts and connectivity associated with essential functions and information shall be identified.
c) Consequences of failures with respect to operation, function or status of the INS shall be identified.
d) Each failure shall be classified with respect to its impact on the INS taking into account relevant characteristics, such as the ability to detect, diagnose, test, compensate and operate.

e) The result of the failure analysis shall confirm the possibility [and provisions] for continued safe operation of the ship.

As a basis for testing the compliance with this requirement, the manufacturer shall:

- outline the minimal configuration of the INS and its optional parts and configurations, including all electrical and electronic interfaces between the parts of the INS and between the INS and other sensors and equipment, both in a simplified graphical and tabular form and in listings of data the INS is capable of transmitting or receiving to and from its parts, other sensors and equipment;
- declare which parts of the INS form the main INS workstation;
- provide evidence, e.g. in the form of presenting type approval certificates that all parts of the INS for which performance standards exist, comply with these standards;
- declare, in a tabular form, broken down by the parts of the INS, and in order of the clauses of this International Standard, where and basically how the INS functions required for the equipment according to their individual performance standard are realised.

9.2 Test power source

During conformance testing the equipment shall be supplied from a test power source, capable of producing normal and extreme test voltages as specified in IEC 60945.

For the purposes of tests, the voltage of the power supply shall be measured at the input terminals of the equipment.[whilst under normal operating conditions][Not agreed, as the basic idea is to make sure that there is no excessive voltage drop on the supply cable. Thus it is valid for both normal and extreme test voltages]

If the equipment is provided with a power cable permanently connected, the test voltage shall be that measured at the point of connection of the power cable to the equipment.

During tests, the test power source voltages shall be maintained within a tolerance of ±3 % relative to the voltage at the beginning of each test.

9.3 Normal test conditions

9.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

9.3.2 Normal test power source

9.3.2.1 Mains voltage and frequency

The normal test voltage for equipment to be connected to the a.c. mains shall be the nominal mains voltage. For the purpose of this standard, the nominal voltage shall be the declared voltage or any one of the declared voltages for which the equipment was designed.

The frequency of the test power supply shall be 50 Hz ± 1 Hz.[60 Hz]

9.3.2.2 Secondary battery power sources

Where the equipment is designed to operate from a battery, the normal test voltage shall be the nominal voltage of the battery (e.g. 12 V, 24 V etc.).

9.3.2.3 Other power sources

For operation from other power sources, the normal test voltage shall be as stated by the manufacturer.

9.4 Extreme test conditions

9.4.1 Extreme temperature

When testing under extreme conditions, the measurements shall be carried out at -15 °C and +55 °C for equipment intended for mounting below deck, and -25 °C and +55 °C for equipment intended for mounting above deck.

Before making measurements, the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilising period. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

9.4.2 Extreme values of test power source

9.4.2.1 Mains voltage and mains frequency

The extreme test voltages for equipment to be connected to an a.c. mains supply shall be the nominal mains voltage ±10 %.

The extreme frequency of the test power supply shall be 50 Hz ± 1 Hz.

9.4.2.2 Secondary battery power sources

When the equipment is intended for operation from a secondary battery power supply, the extreme test voltage shall be 1,3 and 0,9 times the nominal voltage of the battery (e.g. 12 V, 24 V etc.).

9.4.2.3 Other power sources

For equipment using other power sources, the extreme test voltages shall be as stated by the manufacturer.

9.5 Performance checks

9.6 Performance tests

9.7 Performance checks and test for criteria A, B and C (EMC)

9.8 Measurement uncertainty and interpretation of the measuring results.

9.8.1 Measurement uncertainty

[This is taken from a radio standard to make sure the point is not forgotten. Needs to be revised]

[Maximum values of absolute measurement uncertainties shall be

- RF frequency: $\pm 1 \times 10^{-7}$
- RF level: ±0,75 dB
- Audio output power: ±0,5 dB
- Sensitivity of receiver: ±3 dB
- Conducted emission of receiver: ±3 dB

- Two-signal measurement: ±4 dB
- Three-signal measurement: ±3 dB
- Radiated emission of receiver: ±6 dB.

For the test methods according to this standard the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in ETR 028.]

9.8.2 Interpretation of measurement results

[The interpretation of the results recorded in a test report for the measurements described in this standard shall be as follows:

- the measured value, related to the corresponding limit, will be used to decide whether equipment meets the requirements of this standard;
- the measurement uncertainty value for the measurement of each parameter shall be included in the test report;
- for each measurement, the recorded value of the measurement uncertainty shall be equal to or lower than the values in ***.

The use of the measured value has been chosen because there is no other standard covering the subject at the time of publication of this standard. Therefore, the measurement uncertainty shall be used as a quality of the actual measurement.

The measurement uncertainty values may also be used by accreditation authorities during their accreditation procedures to ensure compliance with the requirements of type testing.]

10 Environmental, special and safety tests

10.1 Procedure

Environmental tests shall be carried out before tests of the same equipment in respect to the other requirements of this standard are performed.

Unless otherwise stated, the equipment shall be connected to an electrical power source during the periods for which it is specified that electrical tests shall be carried out. These tests shall be performed using the normal test voltage.

10.2 Required tests

The following tests will be carried out in accordance with the methods of test of IEC 60945:

f) Dry heat storage test for exposed and submerged equipment.

g) Dry heat functional test for protected and exposed equipment.

h) Damp heat functional test for protected and exposed equipment.

i) Low temperature functional test for protected and exposed equipment.

j) Vibration test for all equipment categories.

k) Rain test for exposed equipment.

l) Corrosion (salt mist) test for all equipment categories.

NOTE: The corrosion test shall be waived where the manufacturer is able to produce evidence that the components, materials and finishes employed in the equipment would satisfy the test.

m) Unwanted electromagnetic conducted and radiated emission

n) Immunity to electromagnetic environment

o) Acoustic noise and signals tests for all equipment intended for installation in wheelhouses and bridge wings.

p) Compass safe distance test for all equipment categories except submerged.

q) Test for protection against accidental access to dangerous voltages

r) Electromagnetic radio frequency radiation test.

s) Test for emission from visual display unit (VDU).

NOTE: The safety test for visual display units (VDU) shall be waived where the manufacturer is able to produce evidence that the VDU would satisfy the tests.

t) X-radiation

NOTE: The X-radiation test shall be waived where the manufacturer is able to produce evidence that the equipment would satisfy the test.

11 Technical tests for INS(A)

12 Technical tests for INS(B)

13 Technical tests for INS(C)

Annex A
(Informative)

Clarification of applications of this International Standard, when using 4.2.2

The Performance Standard for Integrated Navigation Systems is different from many other IMO Performance Standards. Most performance standards address one specific piece of equipment. When connections are made to other equipment little is required other than specifying the interface used. Performance Standards for individual equipment do not address the requirements for integrating all possible applications of the equipment that may be interconnected with them.

The INS Performance Standard strives to put forth requirements for this integration of equipment. It lays out functional requirements for integration and use of information within the INS.

The need for this mandate is 4.2.2, which requires ...any combination of navigational aids that provides functions beyond the general intent defined in the respective performance standards... to comply with the requirements of this International Standard.

As the wording ...*provides functions beyond the general intent*... is critical to the understanding of this standard, some examples are given here, for assistance.

A.1 Navigational equipment for which individual performance standards exist and for which this International Standard applies.

A.1.1 Autopilot combined with navigational aids such as GPS, ECDIS, etc.

The combination of an autopilot with navigational aids such as EPFS, ECDIS or any other navigational aid, except a compass, must follow the requirements for an INS(C), when this combination can support automatic control functions of heading, track or speed, because these functions are additional to the general intent of the respective IMO performance standards of the relevant navigational aids.

For instance, the data supplied by a GPS receiver may contain NMEA-sentences APA, APB, and/or HSC for controlling an autopilot, while the IMO Performance Standard for GPS itself does not require this function. The IMO Performance Standard for autopilots does not mention any automatic or automated input of the „heading to steer“ value at all.

A.1.2 Radar/RP combined with chart systems

a) If radar and/or RP are connected to an ECDIS, by the wording of the respective IMO Performance Standards, this does not constitute an INS, because this connection is specified in the ECDIS-Performance Standard. However, if the Electronic Chart System is not an ECDIS, i.e. not type approved as an ECDIS, then such combination constitutes an INS (B) 1.

b) If a radar or RP and a second navigational aid, e.g. an ECDIS are connected to the THD and/or speed sensor(s) and both the Radar/RP and ECDIS are capable to present a “predicted path”, this combination of equipment then constitutes an INS (B).[2]

———————

[2] Such an INS would however not satisfy the IMO requirements for the carriage of charts.

It must for instance follow the principles of “integrity of information”; i.e. it must ensure by its design, that the path predictions of both displays are identical by appearance, accuracy, and identical regarding the source of data.

Although the connection of an RP to ECDIS for the purpose of displaying RP information is specified in the ECDIS performance standard, the additional function of “path prediction” goes beyond the intent of the respective radar or RP standards.

c) When both the radar/RP and the chart system or more than one radar/RP display is capable to present a “planned route" as an aid to monitor the progress along this route, this constitutes an INS (B) and this standard applies.

[For example, it must be ensured, by the design of the equipment or their integrating parts, that the displays cannot show different “planned routes” at the same time without clearly marking the one which is used for the actual navigation and the other(s), which are not, and with consistent markings regardless of the display on which they appear. *(***To be transferred to the requirements of the I.S.) with a cross reference*]

d) When a radar is connected to an autopilot and one of its functions (e.g. the EBL) is used to transfer the "course to steer", this constitutes an INS (C), because these functions are not included in the performance standards of the Radar or Heading Control System, and the Radar is obviously used to control the automatic heading control system.

A.1.3 Use and display of primary navigational data. Radar systems with additional navigation functions

The combination of two RP radars does not constitute an INS. But if additional functions are added to a radar beyond its general intent, e.g. way point navigation, then the whole radar system, including its data feeding sensors, must be designed according to this INS Standard, and in such case the rules for INS (B) [shall] apply.

In this context “primary navigation” data are position, speed, heading, time and water depth (if available due to SOLAS carriage requirements), and their derived data, such as course. The use and display of primary navigation data is required for several navigational aids. Even by normal safety standards, it should be ensured, that different equipment do not use different types of data for an equivalent function without clearly marking their sources. E.g.: The use of “speed over ground” for one RP and “speed through water” for the other, must either be impossible by system design, or must be clearly marked with an appropriate indicator.

A.1.4 Data transfer

A data network can interconnect some navigation equipment. Where this network is used to transfer navigation data in addition to those specified in the relevant performance standard of the transmitting or receiving equipment, e.g. when way point data or course-to-steer-data are included and used by the connected equipment, such functionality constitutes an Integrated Navigation System and must be designed at least according to the category INS (B) specified in this standard.

[If input data, such as “course to steer” is generated from a series of waypoints in one equipment, e.g. the chart system, and automatically transferred to an autopilot, this constitutes an INS (C).

A.1.5 Combination of AIS with Radar or ECDIS.

The combination of radar or RP with AIS for display of target information is not specified in IMO performance standards. (It is not the “general intent” of a radar or RP to display target data other than from its own radar source) Therefore such combination shall only be performed according to this international standard for INS. According to IMO Resolution MSC 86(70) Chapter 2.3, such combination falls under the category of „INS(B) for systems that ... provide the information needed for decision support in avoiding hazards...“

The combination of ECDIS with AIS, by the wording of the IMO resolution A.817 Chapter 4.6.1, may be considered as only providing "...added navigational information..." and hence is not falling under the application of the INS standard. However, when both RP and AIS information can be processed within an ECDIS for co-located or merged target display, at least then such combination of navigational aids provides "...functions beyond the general intent..." and must as well be performed according to this international standard for an INS(B). (It is not the "general intent" of an ECDIS to perform target processing functions for collision avoidance)

NOTE: It is foreseen, that IMO may at a future date submit relevant resolutions or amendments to the present standards for radar, RP or ECDIS, etc., but until such changes become effective this International Standard shall be applied.

A.2 Navigational equipment for which no individual performance standards exist and for which this International Standard applies.

The performance standard for an INS is applicable not only for the combination of navigational aids as defined in 4.2.1, but also according to 4.2.3.1 to 4.2.3.3.

Examples:

A.2.1 INS(A) ... including a consistent common reference system:

(See 4.2.3.1)

a) An interface unit, processing navigational data for use by another navigational aid.

b) A position filter, e.g. a Dead-Reckoning filter built into a GPS receiver, generating a predicted, smoothed, optimised or system position from more than one primary navigation data, for the use in other navigational aids.

c) A position filter, if it is used for supporting the decision which position data input shall be used for navigation.

d) A central navigation information display, e.g. a Conning Display, presenting data or derived information from [combined inputs of] more than one navigational aid. (If the information is related to avoiding hazards, i.e. includes the display of radar targets or charted objects, see 5.2)

A.2.2 INS(B) ... for decision support in avoiding hazards.

(See 4.2.3.2)

a) An electronic chart system, which is not an ECDIS but interfaced to a RP for exchange of data, e.g. for receiving the radar video and presenting it together with the electronic chart [1)].

b) An electronic position fixing system, which is capable to generate the output of waypoints, connected to a radar that automatically receives these waypoints for graphical presentation at the radar screen.

c) A device which processes the data from more than one navigational aid and automatically derives and displays or indicates information of nautical safety related to the planned route, other ships, detected objects or charted objects.

(If the device only derives and displays or indicates information of plausibility, consistency or integrity of primary navigation data, it falls under category INS (A), see 5.1)

A.2.3 INS(C) ... provide the automatic control functions of heading, track or speed:

(See 4.2.3.3)

1) Such an INS would however not satisfy the IMO requirements for the carriage of charts.

a) The term “automatic control functions of heading” is not intended to classify a conventional heading control system (autopilot) as an INS. But when the “course to steer” values are automatically fed into the autopilot from any other navigational aid (see 4.2.1 ... any combination of navigational aids...) then this constitutes an INS(C).

b) Any navigational aid, such as radar, electronic chart, conning display, or position receiver, when intended to be connected to an autopilot, a track controller, a speed controller, the propulsion system or the steering gear directly (except for the connection of the autopilot or track controller itself with the steering gear) constitutes an INS(C) and must be designed and tested according to this standard.

A.3 Navigational equipment and combinations for which this International Standard does not apply

There are a number of navigational equipment and combinations, for which this International Standard does not apply, namely because their integration functions are already included in their performance standards, or do not add functions related to navigation or integrity, consistency or accuracy of navigation data and their display or indication.

Examples:

A.3.1 A combination of radar, RP, EPFS (e.g. GPS), SDME (e.g. EM-Log), ECDIS and/or THD does not constitute an INS

- if the EPFS or ECDIS cannot support way point navigation functions of the radar or RP or vice versa
- if the EFPS does not output a Dead Reckoning Position to the Radar, RP or ECDIS, or vice versa.
- if the EFPS does not output speed data to the radar, RP or THD, except if the EFPS conforms to the performance standards of SDME.
- if the ECDIS does not receive its navigational data (position, heading, and /or speed) from a Radar or RP, or vice versa but is directly connected to the respective sensors.
- if the connected navigational aids do not include functions beyond the general intent of their individual Performance Standards.
- if radar, RP or ECDIS do not include functions of other navigational aids for which a performance standard exists, and which are supported by data or information from another equipment.

A.3.2 A combination of any navigational aid with only an output device, such as a printer, data recorder, remote display or data communication modem, etc., does not constitute an INS.

Definition of the term in clause 4.2.1 " ...beyond the general intent... " :

A function of a navigational aid is beyond the general intent defined in its Performance Standard, when it automatically uses data or information from another equipment for a function not included in the requirements of the relevant Performance Standard.

Annex B
(Informative)

[Integrity Check].
The examples given in this annex B are for information and are not limitative.

1 Position information from the primary EPFS.

#	Method	Equipment required	Method availability	Automatic/Cognitive	User intervention	INS function (Note)
1	Check position with one from secondary independent EPFS	Extra EPFS receiver.	Within extra EPFS availability	Automatic	Not required	INS shall continuously monitor difference between positions to be within limit set.
2	Check position by Dead Reckoning position (water referenced)	THD/Magnetic Compass Water referenced SDME	Within relatively short period of time due to DR method limitations (drift is not taken into consideration, possible log and THD errors. Good enough to check “jumps”	Automatic	User shall check DR position by other means (e.g. visual fix) as frequently as navigational conditions require (drift, devices accuracy etc).	INS should continuously calculate DR position. INS should continuously monitor difference between positions to be within limit set.
3	Check position by Dead Reckoning position (bottom referenced)	THD/Magnetic Compass Bottom referenced SDME	Same as above with better accuracy, but limited to availability of bottom mode of SDME (e.g. h<200m)	Automatic	Same as above. Drift information will be taken care of.	Same as above
4	Check position by correspondence of objects on radar image and those on chart (electronic chart).	Radar ECDIS (RCDS) OR Radar with selected SENC display	Subject to availability of “radar visible” charted objects (e.g. shore, islands, floating aids to navigation)	Cognitive	User shall check positions of objects on radar image and those on chart (electronic chart).	INS shall provide radar image and chart information within one graphical display. CCRS should be applied.
5	Check position with one calculated from fixed RP (ARPA, EPA, ATA) target (Echo Reference)	ECDIS (if requirement of 4.10.5.6 is achieved by continuous position fix based on plotted target fixed to chart object)	Subject to appropriate target availability	Automatic	User shall select reference target(s) and appropriate chart object to start the process. User shall change reference target(s)	INS should continuously calculate ER position. INS should continuously monitor difference between positions to be within limit set.

#	Method	Equipment required	Method availability	Automatic/Cognitive	User intervention	INS function (Note)
		RP (ARPA, EPA, ATA). However, interface to EPFS or ER function is required to ensure ground stabilisation not position fix.			whenever necessary.	
	Check of measured depth information with charted one at current ship's position	ECDIS Echo-sounder	Rather THEORETICAL method	Automatic	Not required (except for draft information input not supported by IEC61162-1 1995)	INS should continuously compare actual depth (measured below transducer and draft) with charted spot sounding at ship's position. For the purpose INS shall provide tidal prediction. Difference shall be monitored to be within a limit set.
7	Check position by correlation of AIS target and Radar information.	AIS Radar with AIS information display	Limited availability It depends on possible THD errors, range of the target its positioning accuracy etc.	Cognitive	User shall check positions of AIS targets on radar image.	INS shall provide radar image and AIS information within one graphical display. CCRS should be applied.
8	Check position by correlation of AIS target (ship) and corresponding RP target.	AIS RP with AIS information display	Limited availability It depends on possible THD errors, range of the target its positioning accuracy etc.	Automatic	User may be required to make initial correlation manually.	INS shall monitor AIS target and corresponding RP target position difference to be within a limit set.
6	Check position by correlation of AIS fixed target (e.g. lighthouse) and corresponding RP target.	AIS RP with AIS information display	Depends on possible THD errors, range of the target.	Automatic	User may be required to make initial correlation manually.	INS shall monitor AIS target and corresponding RP target position difference to be within a limit set.

2. Speed through the water from SDME.

#	Method	Equipment required	Method availability	Automatic/Cognitive	User intervention	INS function (Note)
1	Check speed through the water with SOG from EPFS.	EPFS Tidal current prediction or real time information for OPTIONAL corrections (e.g. within ECDIS).	Use of tidal/seasonal currents prediction improves the accuracy.	Automatic	Not required.	INS shall monitor speed difference to be within a limit set. INS can correct COG/SOG information for predicted or real time tidal/seasonal currents for check purposes.
2	Check speed through the water with ground speed taken by RP echo reference.	RP Tidal current prediction or real time information for OPTIONAL corrections (e.g. within ECDIS).	Subject to availability of appropriate targets. Use of tidal/seasonal currents prediction improves the accuracy.	Automatic	Required for initial reference target selection.	INS shall monitor speed difference to be within a limit set. INS can correct ground speed information for predicted or real time tidal/seasonal currents for check purposes.
3	Check speed through the water with ground speed taken from bottom tracking log.	Bottom log Tidal current prediction or real time information for OPTIONAL corrections (e.g. within ECDIS).	limited to availability of bottom mode of SDME (e.g. h<200m). Use of tidal/seasonal currents prediction improves the accuracy.	Automatic	Not required.	INS shall monitor speed difference to be within a limit set. INS can correct ground speed information for predicted or real time tidal/seasonal currents for check purposes.

3. Heading from THD.

#	Method	Equipment required	Method availability	Automatic/Cognitive	User intervention	INS function (Note)
1	Check heading with magnetic heading corrected by magnetic variation and deviation. OR with the heading from the second THD.	TMHD Magnetic variation database or extra THD	Not limited. Accuracy is lower on manoeuvres.	Automatic	Not required.	INS shall monitor difference in THD reading and magnetic compass reading (the latter should be corrected for deviation and magnetic variation).
2	Check heading with COG from EPFS	EPFS	Method gives reasonably good results on relatively high speed and steady courses. Availability of current and drift due to wind may considerably affect method accuracy.	Automatic	Not required.	INS shall monitor difference in THD reading and COG from EPFS.
3	Check heading with the one from EPFS	EPFS capable to determine ship's hull orientation (heading)	Not limited.	Automatic	Not required.	INS shall monitor difference between THD heading and heading from EPFS.
4	Check heading by correspondence of objects on radar image and those on chart (electronic chart).	Radar ECDIS (RCDS) OR Radar with selected SENC display	Subject to availability of "radar visible" charted objects (e.g. shore, islands, floating aids to navigation)	Cognitive	User shall verify heading by visible bearing offset of objects on radar image and those on chart (electronic chart). In case of heading error all objects should have more or less same bearing offset, so, that radar picture "rotated" over the chart.	INS shall provide radar image and chart information within one graphical display. CCRS should be applied.
5	Check heading by correspondence of objects tracked by RP and those on chart (electronic chart).	ECDIS interfaced to RP or RP with SENC information	Subject to appropriate target availability	Automatic	May be required for initial association of charted object(s) and RP target(s).	INS shall monitor bearing difference of associated objects to be within a limit set.
6	Check heading by correspondence of objects on radar image and those received from AIS.	AIS interfaced to Radar.	Subject to availability of AIS targets.	Cognitive	User shall verify heading by visible bearing offset of objects on radar image and AIS targets. All objects should have more or less same bearing offset, so, that radar	INS shall provide radar image and AIS information within one graphical display. CCRS should be applied.

#	Method	Equipment required	Method availability	Automatic/Cognitive	User intervention	INS function (Note)
					picture “rotated” over the AIS information.	
7	Check heading by correspondence of objects tracked by RP and those received from AIS.	AIS interfaced to RP.	Subject to availability of AIS targets.	Automatic	May be required for initial association of AIS target(s) and RP target(s).	INS shall monitor bearing difference of associated targets to be within a limit set.

Annex C
(Normative)

IMO Resolution MSC 86(70) ANNEX 3

Recommendation on Performance Standards for an Integrated Navigation System (INS)

1 SCOPE

1.1 The purpose of an integrated navigation system (INS) is to provide 'added value' to the functions and information needed by the officer in charge of the navigational watch (00W) to plan, monitor or control the progress of the ship.

1.2 The INS supports mode and situation awareness.

1.3 The INS supports safety of navigation by evaluating inputs from several independent and different sensors, combining them to provide information giving timely warnings of potential dangers and degradation of integrity of this information. Integrity monitoring is an intrinsic function of the INS.

1.4 The INS aims to ensure that, by taking human factors into consideration, the workload is kept within the capacity of the 00W in order to enhance safe and expeditious navigation and to complement the mariner's capabilities, while at the same time to compensate for their limitations.

1.5 The function of passage execution in an Integrated Bridge System (IBS), as defined by the Organization* may be performed by an INS.

2 APPLICATION

2.1 These performance standards are applicable to any combination of navigational aids that provides functions beyond the general intent defined in the respective performance standards adopted by the Organization for individual equipment.

2.2 The purpose of these performance standards is to support the proper and safe integration of navigational equipment and information.

2.3 These performance standards define three categories of INS:

.1 INS(A) for systems that provide the minimum functional requirements of the INS including a consistent common reference system;

.2 INS(B) for systems that, in addition to the' functional requirements of INS(A), provide the information needed for decision support in avoiding hazards; and

.3 IN S(C) for systems that, in addition to the functional requirements of INS(B), provide the automatic control functions of heading, track or speed.

3 DEFINITIONS

For the purpose of these standards the following definitions apply.

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* Resolution MSC.64(67), Annex 1 - Recommendation on performance standards for Integrated Bridge Systems

3.1 **Automatic control system** - A control system that may include a heading, track or speed control system.

3.2 **Consistent common reference system** - A sub-system of an INS for acquisition, processing, storage and distribution of data and information providing identical and obligatory reference to sub-systems within an INS.

3.3 **Integrated navigation system** - An INS is a combination of systems that are interconnected to increase safe and efficient navigation by suitably qualified personnel.

3.4 **Integrity** - Ability of the system to provide the user with information within the specified accuracy in a timely, complete and unambiguous manner, and alarms and indications within a specified time when the system should be used with caution or not at all.

3.5 **Multifunction display** - A single visual display unit that can present, either simultaneously or through a series of selectable pages, information from more than one operation of a system.

3.6 **Sensor** - A navigational aid, with or without its own display and control as appropriate, automatically providing information to the INS.

4 OPERATIONAL REQUIREMENTS

4.1 Functionality

General

4.1.1 In addition to meeting the relevant requirements of resolution A.694(17) *, the INS should comply with the requirements of these performance standards.

4.1.2 Each part of the INS should comply with all applicable requirements adopted by the Organization, including the requirements of these performance standards. Parts executing multiple operations should meet the requirements specified for each individual function they can control, monitor or perform.

4.1.3 When functions of equipment connected to the INS provide facilities in addition to these performance standards, the operation and, as far as is reasonably practicable, the malfunction of such additional facilities should not degrade the performance of the INS below the requirements of these standards.

4.1.4 A failure of one part should not affect other parts except for those functions directly dependent upon the information from the defective part.

Basic functions

4.1.5 An INS should combine, process and evaluate data from all sensors in use. The integrity of data from different sensors should be evaluated prior to distribution.

4.1.6 An INS should ensure that the different types of information are distributed to the relevant parts of the system, applying a 'consistent common reference system' for all types of information.

4.1.7 The INS(A) should as a minimum provide the information of position, speed, heading and time, each clearly marked with an indication of integrity.

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* See also IEC Publication 60945

4.1.8 The INS(B) should be able to automatically, continually and graphically indicate the ship's position, speed and heading and, where available, depth in relation to the planned route as well as to known and detected hazards.

4.1.9 The INS(C) should, in addition, provide means to automatically control heading, track or speed and monitor the performance and status of these controls.

Integrity monitoring

4.1.10 The integrity of information should be verified by comparison of the data derived independently from two or more sources if available.

4.1.11 The integrity should be verified before essential information is displayed or used. Information with doubtful integrity should be clearly marked by the INS and should not be used for automatic control systems.

Data exchange

4.1.12 Stand-alone equipment for which performance standards adopted by the Organization exist, when connected to the INS, should comply with the applicable international standards* for data exchange and interfacing.

4.1.13 Data latency should be consistent with the data requirements of the individual parts.

4.1.14 The integrity of data exchange within the INS should be ensured.

4.1.15 A failure of data exchange should not affect any independent functionality.

Integration

4.1.16 The INS should provide functional integration meeting the following requirements:

.1 where a display or control is presented on a multifunction display unit then these should be redundantly available; and

.2 validity* of the data should be provided for each part to be integrated.

Configuration control

4.1.17 It should be possible to display the complete system configuration, the available configuration and the configuration in use.

4.2 Information and accuracy Display of information

4.2.1 The INS should be able to display the information available in accordance with paragraphs 4.1.7, 4.1.8 and 4.1.9 as applicable.

4.2.2 The INS should be capable of displaying output data available from the sensors.

4.2.3 The information should be displayed together with the indication of its source (sensor data, result of calculation or manual input), unit of measurement and status, including mode (see sub-section Integrity monitoring).

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* IEC Publication 61162

* Resolutions A.529(13) and A.815(19)

Accuracy

4.2.4 As a minimum, the accuracy of information should meet the requirements of the resolutions* adopted by the Organization. Additionally the INS should not degrade the accuracy of the data provided by the sensors.

4.3 Malfunctions, alarms and indications

Fail safe operation

4.3.1 The system's automatic response to malfunctions should result in the safest of any other configuration accompanied by clear indications and alarms.

Reversionary mode

4.3.2 The INS should allow simple and effective operator action to override or by-pass any automated functions. The INS should resume automatic functions only after an appropriate message and intended operator action, considering all necessary starting conditions.

Alarm management

4.3.3 An alarm management system should be provided.

4.3.4 The INS alarm management system, as a minimum, should comply with the requirements of the Organization.*

4.3.5 The number of alarms should be kept as low as possible by providing indications for information of lower importance.

4.3.6 Alarms should be displayed so that the alarm reason and the resulting functional restrictions can be easily understood. Indications should be self-explanatory.

5 ERGONOMIC CRITERIA

5.1 Cognitive ergonomics

5.1.1 Integrated display and control functions should adopt a consistent human machine interface (HMI) philosophy and implementation.

5.1.2 The HMI should be so designed that the provided information is clearly understood using a consistent presentation style.

5.1.3 The HMI should be so designed that the requested manual inputs can be easily executed.

5.1.4 For manual inputs that may cause unintended results, the INS should request confirmation before acceptance, thus providing a plausibility check.

5.2 Physical ergonomics

Controls and displays

5.2.1 Particular consideration should be given to:

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* Resolution A.830(19)

- symbols;
- controls; and
- layout.

Operational controls

5.2.2 The INS should be designed and implemented so that the OoW easily operates basic functions from workstations.

Presentation of information

5.2.3 Continuously displayed information should be optimised and should include position, speed, heading and time. Supplementary information should be readily accessible.

6 DESIGN AND INSTALLATION

General

6.1 The INS should meet the relevant requirements of resolution A.694(17) and appropriate international standards*.

Failure analysis

6.2 A failure analysis** should be performed and documented for the installed configuration of the INS which includes all parts connected to or integrated into the system, including devices for manual override of automatic functions and their locations on the bridge.

Installation requirements

6.3 The INS should be installed so that it can meet the requirements of the relevant International Standards.***

Power supply requirements

6.4. Power supply requirements applying to parts of the INS as a result of other IMO requirements should remain applicable.

6.5 The INS should be supplied:

.1 from both the main and the emergency source of electrical power with automated changeover through a local distribution board with provision to preclude inadvertent shutdown; and

.2 from a transitional source of electrical power for a duration of not less than 45 s.

Power interruptions and shutdown

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* IEC Publication 60945

** See also IEC Publication 61508

*** IEC Publications 92-101 and 533

6.6 After a power interruption full functionality of the INS should be available after recovery of all subsystems. The INS should not increase the recovery time of individual subsystem functions after power restoration.

6.7 If subjected to a power interruption the INS should, upon restoration of power, maintain the configuration in use and continue automated operation, as far as practicable. Safety related automatic functions, should only be restored upon confirmation by the operator.

7 INTERFACING

Interfacing to, and from, the INS should comply with international standards*, as appropriate.

8 FALL-BACK ARRANGEMENTS

8.1 The INS should, after a failure, support the availability of essential information through the use of appropriate fallback arrangements.

8.2 Normal operation, after use of a fallback arrangement, should only be restored upon confirmation by the operator.

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* IEC Publication 61162

Annex D
(informative)

Definition of integration related terms

It is the intent of WG10 to include here an updated version of annex Annex E (informative) of IEC 61209 “Definition of integration related terms” as most terms of this annex are related to navigation and are relevant to this International Standard.

Annex E
(informative)

Bridge Alarm System

(Under development)

This summary contains as many as possible items related to bridge alarm and safety watch keeping. The sources of the information is IMO performance resolutions, individual international equipment standards (including working draft), IACS and major classification society's rules and the report of "ship's alarm study" by the Mercantile Maritime Institute of Japan. For total view, refer to the attached diagram of " Example of Bridge Monitoring & Alarm system"

E.1 Ranking of alarm

E.1.1 Rank 1: Danger to Human or Hull

{Example}:

- Fire
- Poisonous gas detect
- Flood
- Dead ship (Main engine emergency stop and Steering failure)
- Release fire extinguish

E.1.2 Rank 2: Urgent actions are required

{Example}:

- Steering system abnormal (including heading sensor abnormal and heading
- Control system abnormal)
- Navigation lights abnormal
- Vital failure of Machinery (including boiler and generators)
- Rocked in alarm (including elevator and refrigerator)
- Ballast
- Distress alert
- Dead-man on bridge

E.1.3 Rank 3: Abnormal conditions

{Example}:

- Navigation equipment abnormal
- Radio communication equipment abnormal
- Machinery control system abnormal
- Cargo condition abnormal

E.1.4 Rank 4: Notice

{Example}:

- Radio communication in-call
- Office/Engineer call

E.2 Grouping of alarms

E.2.1 General

- Fire
- Flooding
- Locked in refrigerator
- Hospital call
- Locked in troubled elevator

E.2.2 Navigation

- Prevention of Collision related alarms
- Prevention of Grounding related alarms
- Approaching WP
- Course change
- Passed WP
- Lost target
- Intruder
- Off course
- Off track

E.2.3 Distress alerts

- GMDSS

E.2.4 Failure of equipment

According to the alarm required by the individual equipment's standard.

- Steering related alarms
- Traffic surveillance related alarms
- Navigation Lights
- Propulsion control related alarms
- etc.

E.2.5 Miss operation {to be considered with layout and/or protect}

- Miss touch
- Miss select
- Miss setting
- Wrong way

E.2.6 Machinery

	Extension group alarm
- Main engine-propulsion trouble (stop)	Group (A)

- Main engine/propulsion trouble (slowdown) Group (B)
- Auxiliary engine trouble Group (C)
- Boiler trouble Group (C)
- Engine room fire Group (A)
- Released fire extinguish device in Engine room Group (A)

E.2.7 Miscellaneous and others

E.3 Extension system

E.3.1 Alarm transfer system

- A system (watch alarm system) shall be provided on the bridge to verify the fitness of the watch.
- Such a system shall be based on interval checking and shall be adjustable up to intervals of [**12**] minutes.
- Acknowledge push buttons shall be located at the main workstation on the bridge area.
- Acknowledgement of alarms shall only be possible on the bridge. And the system is to provide for the acknowledgement by the officer of the navigational watch at the navigating and traffic surveillance/manoeuvring workstation and other appropriate locations in the bridge from where a proper lookout bay be kept.
- Alarm suppression by persistent pressing of the acknowledge push button is not permitted.
- The system is to be continuously powered and is to have an automatic changeover to a standby power supply in case of loss of normal power supply. Voltage drop of the watch alarm system shall be indicated by alarm.
- If the acknowledged push button will not be pressed within the adjusted time intervals, first, an alarm shall sound on the bridge and if not observed within [**30**] seconds, the alarm shall be transferred to the quarters of the master and, if he deems it necessary, to a selected back-up navigator
- If the alarms are not acknowledged within another [90] seconds the alarms shall be transferred to the general alarm system.
- The alarm/warning transfer shall be operated through a fixed installation. If, depending on the shipboard work Organization, the backup navigator may attend locations not connected to the fixed installation(s), he is to be provided with a wireless portable device enabling both the alarm/warning transfer and the two way speech communication with the officer of the watch.
- Provision is to be made on the bridge for the operation of a navigation officer call-alarm to be clearly audible in the spaces of the bridge and the quarters of the master.

E.3.2 Extension group alarm system

{according to the engine monitoring and alarm system}

E.4 Steps and sequences of confirmation

Refer to the diagrams of “Basic Sequence of Acknowledge on the Bridge” and “Timing chart”

E.5 Devices for awareness

E.5.1 Sound {sound pressure level to be regulated by IEC 60945}

- Siren. May be used for 1st ranked alarm

- Phone. May be used for 2nd ranked alarm
- Bell. May be used for 3rd ranked alarm
- Buzzer. May be used for 3rd ranked alarm
- Chime. May be used for 4th ranked alarm and notice
- Voice.
- A voice annunciator shall be combined with other indications.
- As a minimum
  - English language shall be available.
  - Announcements shall be in plain language using the operators terminology but such that they will not be misunderstood as commands usually given by persons.
  - Methods shall be provided to check the functionality of the voice output and to adjust the necessary volume. It shall be possible to adjust the volume to extinction.
  - Announcements shall be clearly understandable at all possible places where the operator may be situated and under the prevailing environmental conditions.
  - Announcements shall not startle the listener by sudden changes of loudness.
- It shall be possible to acknowledge announcements to stop their repeated output.
- Additional or alternative methods shall be provided to ensure that the operator is addressed even when the voice output system fails.

E.5.2 Indication

- Lamp. May be used for individual indication. {size, shape, colour and brightness are standardised by IEC 60945}
- Rotary light. May be used in Engine room
- Column. May be used in Engine room extension alarms with rotary light.

E.5.3 Visual Display

- Character and Mimic diagram. For size coding, the larger symbol should be at least [**1.5**] times the height of the next smaller symbol. High brightness levels should be used to signify information of primary importance, and lower levels should be used to signify information of secondary interest. Flashing should be used when a displayed item implies an urgent need for user attention, but not in displays requiring attention to detail or reading of text. When a user must read a displayed item that is flash coded, an extra symbol such as an asterisk or arrow to mark the item should be used, and the marker symbol should flash rather than the item itself.
- Colour. Colours for coding should be based on user conventions with particular colours. When colour coding is used, each colour should represent only one category of displayed data.

E.5.4 Mechanical {ideal}

- Vibration
- Shock

E.6 Devices for input and confirmation

Control actions should be simple, particularly for real-time tasks requiring fast user response, control logic should permit completion of a transaction sequence with minimum number of actions consistent with user abilities. Controls should be easily accessible and easy to identify and operate.

- Push button
- Knob
- Lever
- Switch
- Keyboard
- Mice
- Joysticks
- Trackballs

E.7 Protection

Input and control devices should be stable during normal usage, i.e., they should not slip or rock, unless such actions are a part of the controller operation. The system should be designed to prevent the accidental manipulation of control and input devices which could result in changes to the status of the system functions, components, or data.

- Lock
- Cover
- Double action

E.8 Limit Setting

- On/Off
- Limit value
- Early course change
- Time adjust for watch alarm

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